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Control of *Bemisia tabaci* (Gennadius) (Hemiptera: Aphididae) by some herbal extracts and pesticides on cabbage plants

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Abstract
Whitefly *Bemisia tabaci* (Gennadius, 1889) is a polyphagous, highly destructive pest of agricultural crops. Their adults feed on the foliage of cruciferous plants and greatly reduce both yield and quality of the production of cabbage. So this study aims to evaluate the foliar application efficacy of aqueous extracts of *Azadirachta indica* and *Jatropha curcas* seeds powders and *Azadirachta indica* leaves extracts on *Bemisia tabaci* in cabbage farm so that to develop alternatives to chemical control harmful to the environment. In Bongouanou and CBC Kangandissou, the botanicals extracts based on *Azadirachta indica* and *Jatropha curcas*, and the pesticides Decis 12 EC and Cypercal 50 EC were effective against *B. tabaci* adults. The aqueous of *Jatropha curcas* seeds extracts 59.1 g/L and 36.9 g/L and the aqueous extracts from of *Azadirachta indica* leaves 67 g/L have similar efficacy to the pesticides Decis and Cypercal. In the two localities, on the yield, of *Azadirachta indica* seed powders aqueous extracts 41.5 g/L and 25.9 g/L were found the most effective than Cypercal and Decis and *Jatropha curcas* seed powders aqueous extracts 59.1 and 36.9 g/L. Futhermore, *Jatropha curcas* extracts have similar effectiveness as pesticides Decis and Cypercal. Thus, *Azadirachta indica* and *Jatropha curcas* seed powders aqueous extracts could be used to protect crops against *Bemisia tabaci*.

Keywords: *Bemisia tabaci*, biological control, *Brassica oleracea*, plant extracts

Introduction
Whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is a highly destructive agricultural pest that is capable of vectoring viruses in most agricultural crops [14, 16, 26]. *B. tabaci* is a species complex composed of many morphologically indistinguishable biotypes [16]. Adults and larvae of *B. tabaci* generally locate on the underside of the leaves where they suck the sap and transmit more than 110 viruses to plants [13, 20]. They are phloem-feeding pests damaging food and fibre crops and ornamental plants [6] and reducing yield in a broad range of fibre, vegetable and ornamental crops [3, 16]. The sucking of the sap weakens the plant and causes physiological disorders, in particular dwarfism and nervous chlorosis, resulting in the death of the plants [4, 26]. *B. tabaci* is polyphagous species which infest more than 600 species of plants, including cabbage, tomato, cotton, cucumber, sweet pepper, and other economically important species [14, 19, 26]. The high temperature of this season favors their reproduction and their migration to crops [25]. Cabbage whiteflies causes severe damage to Brassica vegetables and yield losses through extracting phloem sap and producing honeydew secretions especially on kale [15]. Resistance of *B. tabaci* to conventional insecticides was observed in tropical, subtropical and Mediterranean areas [1, 23] and yield losses can be often up to 100% [1]. The developments of resistant cultivars and biological agents such as parasitoids, predators and entomopathogens have been used to control the resistance developed by *B. tabaci* [25, 24]. The crude extracts obtained from plants are usually composed of terpenoids and compounds such as secondary metabolites [22]. The plant secondary compounds have been the subject of thorough investigation for the past few years in an effort to discover new sources of botanical insecticides and other behaviour regulating chemicals [22]. The objective of the present experiment was to study the effectiveness of two medicinal plants extracts on the variation in population dynamics of *B. tabaci* and the yields of cabbage in east-center of Côte d'Ivoire.

Materials and Methods
Study area
Cropping trials were conducted in Bongouanou and CBC Kangandissou, located in east-central of Côte d'Ivoire (6°38'55'' N, 4°11'57"W) (Table 1).

The experimental design was a fisher block with three repetition in Bongouanou and CBC Kangandissou. Each unit plot measuring 5 m on 1 m. Each elementary plot has 3 lines of cabbage plants spaced to 0.40 m.

Table 1: Cabbage culture carried out in Bongouanou and CBC Kangandissou

Trial	Cultivar	Transplant date	Period	Season
Bongouanou	*Brassica oleracea*	21 August 2012	21/8/12 – 02/11/12	Reany season
CBC Kangandissou		1 February 2013	01/2/13 – 08/5/13	Dry season

Plant extracts and pesticides

Two medicinal plants *Azadirachta indica* A. Juss (Sapindales: Meliaceae) and *Jatropha curcas* L. (Malpighiales: Euphorbiaceae) were used in this study. *Azadirachta indica* and *Jatropha curcas* seeds, and *Azadirachta indica* leaves were collected from natural habitats in Bongouanou. Seeds and leaves were air-dried for four weeks at room temperature (30 ± 2º C) and a relative humidity of 72 ± 5%. The dried seeds of *A. indica* and *J. curcas* were cleaned, de-shelled and subsequently the kernels and hulls were separated manually. The kernels and leaves of *A. indica* and *J. curcas* were grounded to fine powders using a sieve of 500 µm and finally extracted with 10 liters of water at room temperature for one day (Table 2). After 24 hours of maceration, the solutions were filtered through a very fine mesh sieve (0.2 mm). The treatable area of 10 L of each botanical extracts was 200 m^2 [2].

Two pyrethroids, Decis (Delthamethrin, 12 EC, AF- CHEM SOFACO, Côte d´Ivoire) and Cypercal (Cypermethrin, 50 EC, AF- CHEM SOFACO, Côte d´Ivoire) were examined on the abundance of B. tabaci and the yield of cabbage (Table 2). 40 mL of Cypercal or 50 mL of Decis were mixed in 15 L of water to spray 400 m^2 and 500 m^2, respectively.

Field efficacy trial

Using a backpack sprayer, the pesticides Decis and Cypercal and plant extracts of *A. indica* and *J. curcas* were used for plots treatments. A control plot that received no treatment. Treatments were done weekly from 6 am to 8 am [17, 10]. The first foliar applications in the field were made on the 3rd day after transplanting of plants

Whitefly *Bemisia tabaci* adults had been recorded on cabbage (*Brassica oleracea* var capitata) at 13th day after transplanting to the 48th day after transplanting [11, 18]. They were carried out from 6 am to 8 am weekly three days after each treatment on 12 plants in the of each elementary plot. During each observation, the undersides of the upper leaves of the cabbage plants were observed.

Table 2: Plant extracts and pesticides applied in Bongouanou and CBC Kangandissou on cabbage plants

Scientific name	The part of plant powders or pesticides used	Concentration
Azadiracta indica	seeds	41,5 g/L (T1) 25,9 g/L (T5)
	leaves	67 g/L (T3)
Jatropha curcas	seeds	59,1 g/L (T2) 36,9 g/L (T6)
Pesticides	Decis	12 EC (T4)
	Cypercal	50 EC (T7)

Production evaluation

The yields were evaluated from the weight of the cabbage plants by one square meter and is reduced to the hectare (R) by treatment according to the following formula:

R (kg / ha) = P (kg) x 10,000 / S (m^2); where P is the total weight of cabbage harvested from an area S.

Statistical analysis

Statistical analysis were used for the comparisons of the effectiveness between the two plant extracts and pesticides on the frequency of *Bemisia tabaci* on cabbage plants and the cabbage yield. The data were analyzed by oneway Analysis of Variance (ANOVA) and the means were separated using the Fisher test (LSD) with a significance level of 5% using Microsoft SPSS software version 22.0 (IBM, New York, USA) and XLSTAT 2016.

Results and Discussion

Effect of treatments on the abundance of *B. tabaci* on cabbage plant

In Bongouanou, the botanicals extracts of *Azadirachta indica* and *Jatropha curcas* tested significantly reduce ($P < 0.05$) the number of *B. tabaci* compared to the control (To) ($P = 0.00$). The aqueous extracts of neem grain powders 41.5 g / L (T1) and of Jatropha 36.9 g / L (T6) have the same efficacy with a rate of 0.06 adult of *B. tabaci* per plant. The aqueous extracts T1 and T6 have a low efficacy compared to that of the aqueous extracts of neem leaf extract 67g / L (T3) (0.02 adult *B. tabaci* per plant), of neem grains 25.9 g / L (T5) (0.03 adult *B. tabaci* per plant), jatropha grains 59.1 g / L (T2) (0.04 adult *B. tabaci* per plant) and Decis (T4) (0.03 adult of *B. tabaci* per plant) and Cypercal (T7) (0.03 adult of *B. tabaci* per plant). These aqueous extracts (T2, T3, T4, T5, T7) considerably reduce the number of *B. tabaci* adults on cabbage plants (Table 3).

In CBC Kangandissou, all seven treatments applied to cabbage plants significantly reduced the number of *B. tabaci* per plant compared to the T0 control ($P = 0.00$). Aqueous extracts of neem seed powders 41.5 g / L (T1) are the most effective products. They were considerably reduced the number of *B. tabaci* per plant compared to aqueous extracts, powders of jatropha grains 36.9 and 59.1 g / L, neem grains 25.9 g / L (T5), pasta of neem leaves 67 g / L (T3) and the insecticides Decis (T4) and Cypercal (T7).

The aqueous extracts of neem leaf extract, insecticides Decis and aqueous extracts of jatropha grain powders are more effective on *B. tabaci* than the aqueous extracts of neem grain powders 25.9 g / L and the Cypercal which have the same efficacy (0.23 adult *B. tabaci* per plant). The aqueous extract of jatropha grain powders 59.1 g / L was not very effective on adults of *B. tabaci* per plant (0.29) of cabbage in this locality (Table 3).

Effect of treatments on cabbage yield

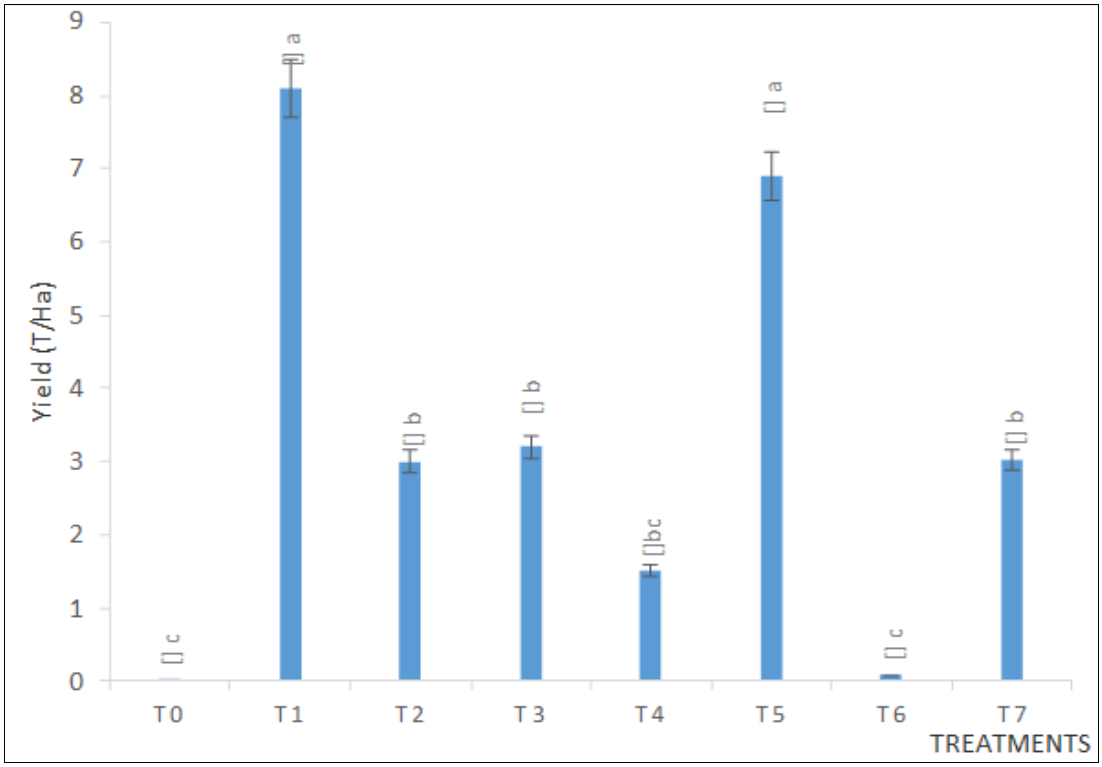
The yields obtained in the plots treated with the different products were significantly higher than that of the controls plots in Bongouanou ($P = 0.0001$) (Figure 1) and in CBC Kangandissou ($P=0.001$) (Figure 2). In the two localities, the yield increased in the plots treated with aqueous extracts of neem seed powders 41.5 g / L and 25.9 g/L than plots treated with the insecticides Cypercal 50 EC and Decis, and with

other botanicals extracts. The yields of the plots treated with the aqueous extracts of neem leaf pasta 67 g / L and aqueous extracts of powders of jatropha seeds 59.1 g/L and 36.9 g/L were similar to those of the plots treated with Cypercal 50 EC and Decis 12 EC in Bongouanou (Figure 1) and in CBC Kangandissou (Figure 2).

Table 3: Effect of insecticides and aqueous extracts of neem and jatropha on populations of *B. tabaci* adults on cabbage

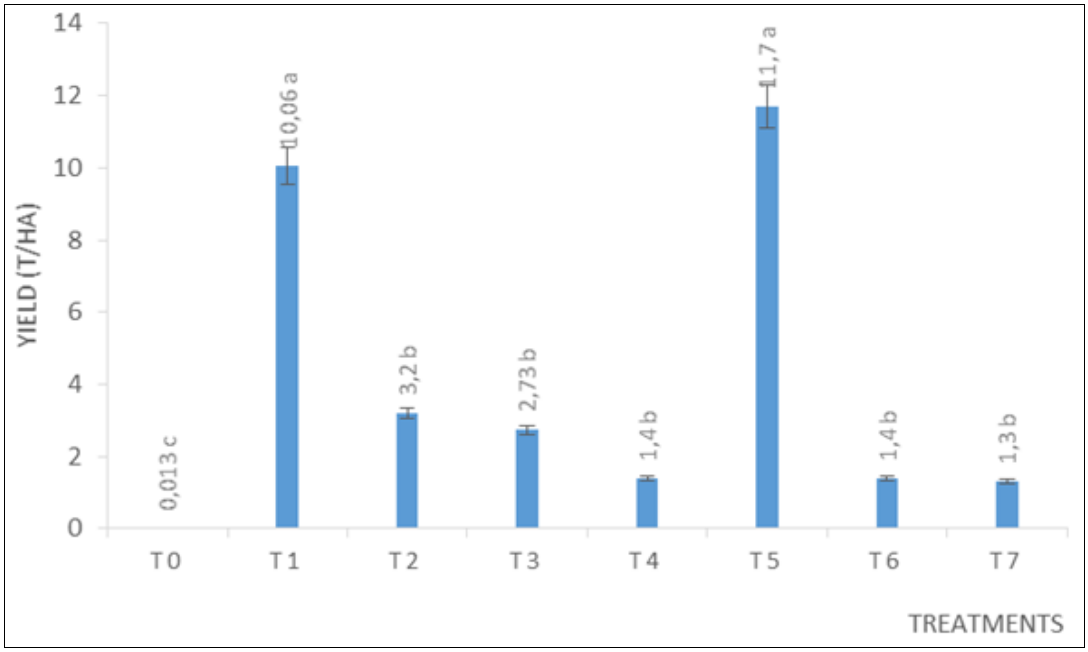
Study area	Season	Treatment	Number of adult *Bemisia tabaci* per plant	CV (%)
Bongouanou	Rainy season	T0	0.12c	7
		T1	0.06b	8
		T2	0.04a	9
		T3	0.02a	5
		T4	0.03a	9
		T5	0.03a	9
		T6	0.06b	8
		T7	0.03a	9
P-value		0.0001		
CBC Kangandissou	Dry season	T0	0.34e	8
		T1	0.12a	5
		T2	0.29d	9
		T3	0.14b	5
		T4	0.15b	9
		T5	0.23c	9
		T6	0.15b	8
		T7	0.23c	7
P-value		0.0001		

CV : Coefficient of Variation; T0: Untreated; T1: Neem grain powders 41.5 g / L; T2: Jatropha grain powders 59.1 g / L; T3: Neem leaf pasta 67 g / L; T4: Decis; T5: Neem grain powders 25.9 g / L; T6: Jatropha grain powders 36.9 g / L; T7: Cypercal
The means assigned to the same letter within the same column are not significantly different for the 5% Fisher test (LSD).



T0: Untreated; T1: Neem grain powders 41.5 g / L; T2: Jatropha grain powders 59.1 g / L; T3: Neem leaf pasta 67 g / L; T4: Decis; T5: Neem grain powders 25.9 g / L; T6: Jatropha grain powders 36.9 g / L; T7: Cypercal

Fig 1: Effects of insecticides and aqueous extracts of neem and jatropha on cabbage yield in Bongouanou plots



T0: Untreated; T1: Neem grain powders 41.5 g / L; T2: Jatropha grain powders 59.1 g / L; T3: Neem leaf pasta 67 g / L; T4: Decis; T5: Neem grain powders 25.9 g / L; T6: Jatropha grain powders 36.9 g / L; T7: Cypercal

Fig 2: Effects of insecticides and aqueous extracts of neem and jatropha on cabbage yield in CBC Kangandissou plots

Our results indicate that *Jatropha curcas* and *Azadirachta indica* seeds powders extracts and of *Azadirachta indica* leaves as well as insecticides, reduced the number of *B. tabaci* on cabbage plants and increased yields. Similar results were reported by Jide-Ojo and Ojo 2011 [12] and Diabaté *et al*. 2014 [8]. According to Jide-Ojo and Ojo 2011 [12] and Diabaté *et al*. 2014 [8], *Azadirachta indica* and *Jatropha curcas* aqueous extracts had toxicity, antifeedent and repellent effect on insect pests. *Azadirachta indica* and *Jatropha curcas* extracts acts as potential insecticide to the adults of *B. tabaci*. They remarkably reduced the number of *B. tabaci* adults on cabbage plants. These botanical extracts used in field have an effectiveness comparable to that of the pesticides Decis and Cypercal commonly used by farmers. Devappa *et al.* 2010 [7] and Jide-Ojo and Ojo 2011 [12] reported that the phytochemicals of *Jatropha curcas*, such as tannins, saponins curcin, and a very small amount of flavonoids and diterpenoids have possess strong activities against several plant pathogens and pests. *Azadirachta indica* extract contained terpenoids including azadirachtin, nimbine, salanine and sterol [9] and other substances, particularly saanine and meliantriol [21] which are toxic to *B. tabaci* eggs and adults [5]. According to Zhao *et al*. 2014 [27], Azadirachtin inhibits the growth of insects by preventing the synthesis of ecdysteroids by inhibiting the protothoracicotropic hormone which blocks moult and thus interrupts their reproductive cycle. It inhibits the growth that affects spawning and moulting and larval development.

Conclusion

On farm, Jatropha and neem seeds powders aqueous extracts and of neem leaves as well as insecticides, reduced the number of *Bemisia tabaci* on cabbage plants and increased yields. These aqueous extracts have similar effectiveness as pesticides Decis and Cypercal. *Azadirachta indica* seeds powder aqueous extracts 41.5 g/L and of *Jatropha curcas* seeds powders 59.1 g/L could be used to protect Brassica plants against *Bemisia tabaci.*

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